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Criteria for Vibration Testing

A proposed approach for analyzing transient flight environments and specifying laboratory vibration tests to simulate these environments uses a systematic application of response spectra analysis, augmented by other analyses, to determine the damping sensitivity of both the flight environment and the candidate laboratory tests.

A computerized comparison is made between the response spectrum for the flight environment, or an enveloping spectra for a collection of flight events, and the response spectrum for a candidate laboratory test. A ground rule for comparison is that the test spectrum must always exceed the flight spectrum. Within the context of this ground rule, parameters governing the test are varied to produce a minimum figure of merit indicating the best possible match of flight and test spectra. Other possible tests, e.g., sweeping sinusoidal vibration, rapid sine sweeps, and half-sine pulse shock tests, are similarly analyzed. Figures of merit for the optimum version of each test are then compared in order to determine which type of test best simulates the flight environment.

Since damping for flight hardware is generally not well defined, a good laboratory test is one in which the optimized parameters based on the figure of merit determination change as little as possible when damping is varied in the spectral analysis. The trade-off between the magnitude of the figure of merit and the damping sensitivity of optimum parameters can be expected to produce a good laboratory test which is representative of the transient flight environment.

With the method described, the conventional sine sweep test has proven to be less satisfactory for simulating a particular, but representative, set of flight transient environments, than has a transient-type test, e.g., a sum of decaying sinusoidals. However, because of its widespread use, conventional sine sweep testing, is investigated in detail, and a set of equations are provided, enabling the analyst to construct an accurate response spectrum which takes into account the reduction of peak response due to sweeping and the off-resonant response of systems having resonances outside the range of the sweep.

Also treated was the question of whether or not a laboratory test and a flight transient having similar response spectra produce similar responses in a spacecraft. Models of typical spacecraft were analyzed by computer, and the correlation between responses and figures of merit was quite good. The conclusion was that spectral methods are useful tools for the stated purpose, if applied carefully and systematically.

Note:

The following documentation may be obtained from:

National Technical Information Service
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $0.95)

Reference:
NASA-CR-91356 (N68-12955), The Study of Mechanical Shock Spectra for Spacecraft Applications

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